U S Fish and Wildlife Service
6578 Dogwood View Parkway
Suite A
Jackson, Mississippi 39213

October 16, 2000

Colonel Robert Crear
District Engineer, Vicksburg District
U.S. Army Corps of Engineers
4115 Clay Street
Vicksburg, MS 39183-3435

Dear Colonel Crear:

We have reviewed Appendix 14: Endangered and Threatened Species Biological Assessment of the Draft Yazoo Backwater Area, Mississippi Reformulation Report which was released to the public during September 2,000. As described in the draft Supplemental EIS, the Biological Assessment (BA) was submitted to the Service pursuant to Section 7 of the Endangered Species Act, as amended. Our response is provided in accordance with these consultation provisions (87 stat. 884 as amended; 16 U.S.C. 1531 et seq.).

Section 7 regulations require Federal agencies to initiate formal consultation if their actions "may affect" listed species or critical habitat (50 CFR § 402.14). One of the purposes of a BA is to enable the federal action agency to determine whether the action may adversely affect listed species and whether to initiate formal consultation (50 CFR § 402.12). We concur that the project is not likely to adversely affect the Louisiana black bear, a threatened species, and formal consultation for this species is not required. The Louisiana black bear is not currently known to permanently inhabit or reproduce in the project area. We disagree, however, with the Corp's conclusion that the Yazoo Pumps Project is not likely to adversely affect pondberry, a federally listed endangered species. We find that this project is likely to adversely affect pondberry. The Corps should initiate formal consultation with the Service to insure this project will not likely jeopardize the continued existence of pondberry, as required by section 7(a)(2) of the Act.

Our review of the pondberry BA is provided in the attachment to this letter. We considered different sources of scientific evidence, including that for pondberry, the ecology of bottomland hardwood communities, the methods and rationale for certain forms of statistical analysis, and the ecology of related patterns and processes. According to the BA, the hydrology and ecology of pondberry is not affected by overbank flooding, but is dominated by the local ponding of rainfall. We find that no substantial scientific evidence is presented to establish this claim. Similarly, we find that the magnitude of reduction in flooding by this project is likely to adversely affect pondberry.

To coordinate the Section 7 evaluation with the schedule of the NEPA process, the Service normally reviews biological assessments of major construction projects prior to the release of a draft EIS. In this instance, the Corps did not provide us with the pondberry survey data, pondberry report, and associated BA before it was published in the draft EIS. During our meeting with your staff on September 6, 2000, however, we were informed that the conclusions in this BA and draft EIS were not necessarily final, and that informal consultation may still be beneficial. If this is still your position, we should meet as soon as possible to continue informal consultation.

We previously informed the Corps during April 2000 that this project may adversely affect pondberry. Subsequently, the BA was published with the draft EIS and your finding of not likely to adversely affect pondberry. We would be pleased to discuss our evaluation of this BA and consider your response. Without any new and substantial data documenting the role of local ponding rather than overbank flooding as the natural source of hydrology to pondberry in the Yazoo Basin, however, we are unlikely to change our finding that the project is likely to adversely affect this species. Such data on local ponding is particularly important for the pondberry colonies where frequent inundation from overbank flooding would be reduced by this project. Our primary purpose in continuing informal consultation at this time would be to prepare for formal consultation. If you disagree, then a continuation of informal consultation on the effects of this project is not likely to be productive.

Finally, new information was presented in this BA concerning the elevation and floodplain of pondberry colonies recently surveyed on the Delta National Forest. This information was not available during our previous review of the BA for the Big Sunflower River Maintenance Project . In the attached review, we have asked several questions concerning the previous biological assessment on the effects of the Big Sunflower River Maintenance Project. On May 6, 1994 we concurred with your assessment that the Big Sunflower Project would not likely adversely affect pondberry. Whether or not we recommend that formal consultation should now be initiated on the effects of the Big Sunflower River Maintenance Project to pondberry will depend in part on your response to these questions.

Sincerely,

Ray Aycock
Field Office Supervisor

cc:

Mr. Larry Moore
Delta National Forest District Ranger
U.S. Forest Service, Rolling Fork, MS

Dr. Sam Polles
MS Department of Wildlife, Fisheries and Parks
Jackson, MS

U.S. Fish and Wildlife Service Review of Appendix 14: Pondberry Biological Assessment

Summary

The COE has concluded that project induced reductions to the frequency and magnitude of flooding by the Yazoo Area Pump Project are not likely to adversely affect pondberry. This conclusion is contrary to the established ecological principles of bottomland hardwood plant community ecology. The composition and distribution of species in bottomland hardwood forest communities is affected by the hydroperiod. The hydrologic features of these communities are dominated by the timing, frequency, and duration of flooding. In the Yazoo Basin, pondberry is a component of bottomland hardwood communities. Thus, a reduction in flooding may adversely affect pondberry.

The COE decided that the local ponding of rainfall in small surficial depressions, rather than overbank flooding, is the dominant source of standing water and the hydrologic regime of pondberry sites in the Basin. By this rationale, any reduction to flooding will not affect pondberry because flooding does not affect wetland hydrology and the habitat for pondberry. The Service finds that this conclusion is more accurately represented instead as an untested hypothesis. No direct scientific evidence was presented to document the actual surficial and hydrologic characteristics by which local rainfall is ponded, the depth of standing water, the area covered by standing water, or the frequency and duration of such ponding relative to the 62 pondberry colony sites that were surveyed Furthermore, statistically inappropriate methods of survey and analysis were used to erroneously infer the absence of any ecological relationship or effect of flood frequency upon the distribution, abundance, and performance of pondberry.

During 1991 - 1994, the Service and MS Department of Wildlife, Fisheries and Parks identified two depressional ponds with pondberry, collectively about six acres in extent, in the Delta National Forest. Standing water in these distinctive ponds, which are the localities for four pondberry colonies surveyed by COE, was derived from rainfall during non-flood years. During flood years, the ponds stored rain and flood water. While the hydrologic regime of pondberry can be affected by ponding and flooding, the best available scientific evidence reveals that depressional storage and ponding of rainfall into the growing season is an unusual hydrogeomorphic feature for pondberry in the Basin.

For the purposes of section 7 consultation under the Endangered Species Act, the Service can only concur with a findng of “not likely to adversely affect” if all impacts of the project are either 100% beneficial, discountable, or insignificant. Substantial scientific evidence reveals that the direct and indirect effects of flooding to hydrology and pondberry cannot be discounted or made insignificant. The U.S. Fish and Wildlife Service must conclude that this project may adversely affect pondberry. Accordingly, we recommend that COE initiate formal consultation under section 7(a)(2) of the Endangered Species Act to insure this project will not jeopardize the continued existence of this species.

1. Introduction

This attachment provides the Service's finding, in contrast to that of the COE, that the proposed project may adversely affect pondberry, a federally listed endangered species. Accordingly, the Service has recommended the COE to initiate formal consultation. The primary COE document reviewed for this evaluation is the COE Yazoo Backwater Area Reformulation Report, Vol. 3, Appendix 14 Endangered and Threatened Species Biological Assessment. Other related documents and issues to this proposed action, commonly known as the Pumps Project, also are considered and described herein.

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, requires that each Federal agency "shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency (hereinafter in this section referred to as an 'agency action') is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification" of critical habitat. The requirements of the consultation process are further described in sections 7(a)3 - 4 of the ESA and by regulations at 50 CFR § 402. Further guidance is provided by the Service's Consultation Handbook (Service 1998).

The COE is required "to determine whether any action *may affect* listed species or critical habitat" (50 CFR § 402.14). To date, the Service and COE have been engaged in "informal consultation" concerning the Yazoo Backwater Area Reformulation project (Pumps) and its effect on pondberry. Informal consultation (50 CFR § 402.13) is an optional process when the Service deliberates with and assists the Federal agency in determining whether formal consultation is required. "If during informal consultation it is determined by the Federal agency [COE], with the written concurrence of the Service, that the action is not likely to adversely affect listed species or critical habitat, the consultation process is terminated and no further action is necessary" (50 CFR § 402.13). If, on the other hand, the COE determines that the action "may affect listed species or critical habitat", then formal consultation is required (50 CFR § 402.14).

<u>April 7, 2000 Meeting</u>

On April 7, 2000 in a continuation of informal consultation, the Service (U.S. Fish and Wildlife Service 2000) provided comments on its review of the COE's internal draft of Appendix 14, Draft Endangered and Threatened Species Biological Assessment. The COE concluded in this draft that the project would not adversely impact pondberry:

> "Previous field surveys and consultation with experts (Corps, 1991) indicate that local hydrology is more important to the growth and health of pondberry than overbank flooding. Only those drainage activities which significantly alter the local hydrological regime of depresssions, ponds, sinks, or other areas governed by localized hydrology would affect pondberry colonies. Implementation of the recommended plan would not alter the hydrological regime of ponds, sinks, or other areas governed by local hydrology. Flooding of these areas would still occur at the same frequency." pg. 12-14.

The Service disagreed with this and other elements of the draft assessment, responding that:

- **The report incorrectly states that pondberry colonies are likely located above the 15-20 year flood event. From elevation and flood gauge data provided by COE, pondberry also appears to inhabit areas subject to more frequent 2-5 year flood events. Thus, pondberry was apparently subject to frequent flooding.**

- **The location of pondberry on ridges, as described by the COE, contradicted other statements that local ponding in sumps and swales was the most important hydrological factor for pondberry. Also, COE had stated that "32 of 44 colonies had no indication of standing water within the colony", which also contradicted claims of local ponding.**

- **Overbank flooding, in addition to any local ponding, is an important hydrologic factor, and that "a reduction in overbank flooding associated with the pump could adversely impact pondberry located on ridges." Additional data on the elevation of the known pondberry sites should be acquired to tabulate the number of pondberry sites according to flood stage and frequency.**

- **The proposed flood elevation for the operation of the Pump, which is below the 2-year flood event, can lead to further clearing of bottomland hardwoods and wetlands that may affect pondberry. Also, the reforestation plan is not a beneficial effect to pondberry because the ecology of this species is not consistent with that of a colonizer that could naturally spread and rapidly inhabit any such reforested areas.**

<u>April 27, 2000 Meeting</u>

On April 27, 2000 the Service and COE met to further discuss the issues in the draft Appendix for pondberry. The major issues and elements of discussion are described below.

- **Current Flood Frequency Baseline for Pondberry**

The Service considered this a significant issue for two reasons. First, the draft BA only described the average elevations of pondberry, at the 15-20 year floodplain. Biological effects occur to individual plants at individual localities, and not to pondberry at "average" elevations. Pondberry also occurred at lower elevations, subject to more frequent flooding, that would be reduced by the project.

Second, the COE analysis of the effects of the project on pondberry when located at or higher than the 15-20 year floodplain was derived in part from the 1990 "Pondberry Profile Workshop." hosted by Geo-Marine, Inc. and COE (U.S. Army Corps of Engineers 1990). According to COE, the workshop participants' opinion was that pondberry located at or higher than the 15-20 year floodplain would not be affected by a reduction in flood frequency or duration. Furthermore, "local drainage/surface water hydrology seemed more important to Pondberry's habitat requirements than

overbank flooding particularly for these colonies located at or near the peripheral of 20-year floodplain" (U.S. Army Corps of Engineers 1990). The group of pondberry experts could not concede, however, that reducing flood frequencies below the 15-20-year floodplain would not affect pondberry.

As the Service discussed, a principal part of the COE analysis on the current project (Pumps) as well as that on past projects (e.g. Steele Bayou) has been that pondberry was located at or above the 20-year floodplain where it would not be affected by any further reduction in flooding. The location of pondberry at more frequently flooded sites, below the 20 year floodplain, may be affected by the proposed project, at least according to the conclusion of the COE's workshop participants. Thus, the existence of pondberry on these lower floodplains as indicated in the Delta National Forest would indicate the need for formal consultation. Additional surveys were recommended.

Mr. Larry Banks (COE) reviewed how COE had determined the frequency and elevation of flood events. Subsequently, the group discussed the need to attain elevation and floodplain data for all known pondberry, especially on the lower end of the Delta National Forest.

- **Hydrology and Pondberry Surveys**

The group briefly discussed the roles of flooding versus local hydrology (e.g. ponding). The COE expressed a view that since pondberry was known to occur on a 100-year floodplain in the Yazoo Basin, then flood frequency does not appear to limit pondberry.

The Service responded that the current frequency of flooding is an artifact of the reduction of flooding from past COE flood control projects. The best available evidence from Galloway (1980) is that the entire Yazoo Basin, under historic natural flooding, was mostly inundated by a 5-year flood event. Flood control projects have reduced flood frequency so that today, portions of the Basin exist on a 100-year floodplain. Also, the existence of pondberry, in contrast to its absence, is not an indicator of viability. Without monitoring or other demographic data, there is no available information to indicate whether existing pondberry colonies are declining, stable, or increasing in size or viability.

The proposed pumping elevation, at 87', would reduce flooding to most of the pondberry currently known on the Delta National Forest, including colonies at or below the approximate 5-year flood stage. Many of these and other pondberry localities at lower elevations have not been surveyed. The current draft assessment is based on pondberry surveys conducted in 1993 for the Big Sunflower Project phase of the Reformulation. Additional surveys are needed.

May 5, 2000 Meeting

The Service and COE met to review the protocols for additional pondberry surveys. The data variables and survey methods for the existing COE "Pondberry Data Form" were reevaluated. The group discussed how to circumscribe the appropriate experimental or sampling units and obtain additional data depicting the amount of pondberry and indicators of growth and die-back.

- **Survey Locations**

Information from surveys by the U.S. Forest Service on Delta National Forest should be assembled and tabulated to describe the areas surveyed, areas not surveyed, and the locations of known pondberry sites. The Service recommended that additional surveys and samples should be acquired both on and off the Delta National Forest.

- **Elevation and Flood Stage**

The elevation of each pondberry survey site should be determined and evaluated relative to the current flood frequency and the change in flood frequency after the project.

- **Sampling Methods**

Sampling at pondberry localities should be stratified according to homogeneous environmental units. These experimental units would represent areas of similar vegetation, soils, and hydrology. The units should reflect differences between pondberry occurrences in depressions, flats, ridges, and other attributes. Samples from plots or quadrats should describe dominant species in the overstory, understory, and herbaceous layer. Sample data should also assess the abundance of pondberry, plant height, and the number of live and dead stems. Fish and Wildlife Service staff should be further consulted in the field about the methods to sample in homogeneous experimental units and to consistently identify and count live and dead stem growth units.

May 30, 2000 Correspondence

After the May 5 meeting with COE, the Service learned that COE had initiated additional field surveys. The Service was concerned since the sampling and survey protocol can require modifications in response to site-specific environmental conditions and the amount and distribution of pondberry. Mr. Ray Aycock, Field Supervisor Mississippi Field Office, corresponded with Col. Robert Crear to emphasize the need for appropriate sampling units, consistency in measuring the variables in each unit, and the Service's desire to accompany the COE contractor to observe and recommend adjustments to field sampling methodologies. In addition, an Appendix was provided to further describe the sampling protocol recommended by the Service. As part of the recommended protocol analysis, the relationship of pondberry localities to the historical flood regime, prior to flood control, should be evaluated.

June 9, 2000

Service staff from the Jackson Field Office were invited to accompany the COE and its contractor (Gulf South Research Corporation) during pondberry surveys on the Delta National Forest. Two pondberry sites previously identified by staff at the Delta National Forest were surveyed. This was the first opportunity for the Service to illustrate to the survey crew the characteristic of pondberry stem cankers, presumably caused by the pathogen Diaporte sp.. The surveyors at these sites, and at sites previously surveyed in the company of other Service staff in Boliver County on May 4, did not determine canopy cover using a densiometer. Also, surveyors did not determine "average" plant height as computed from a sample of individually measures stems. Since the densiometer was mistakenly left at the office, according to the contractors, canopy cover was visually estimated without the aid of an instrument. "Average" plant height also consisted of the surveyors visually selecting a plant that was considered to be "representative", and measuring the height of this plant. At the end of the day, the Service was informed that the pondberry sampling had been completed, e.g. all sites scheduled to be sampled had been surveyed. Another crew would follow the survey to determine the actual elevation of sites from a known elevation benchmark.

August 15, 2000

The Service and COE conferred by telephone, at which time the Service was informed that the COE contractor had not completed and submitted the final pondberry report. After COE had an opportunity to review the report, they would meet with the Service before making their final determination of whether the project may affect pondberry and releasing their report to the public.

August 31, 2000

A news article in the Vicksburg Post announced that the COE would make available to the public the COE Reformulation Report on September 2, via the Internet. By a phone call to the COE, the Service was informed that the report contained the conclusion that the project will not likely adversely affect pondberry. COE planned to release the draft EIS to public in the Federal Register on September 15.

September 6, 2000

The Service and COE met to review Appendix 14, as recently released to the public on the internet. Since the COE had yet to submit the report to the Service, the Service had not completely reviewed the recent report as released on the internet. Thus, the COE briefly reviewed the main elements of the report and responded to the Service's initial questions.

The Service inquired whether the COE had made a determination in the draft EIS that the project will not likely adversely effect pondberry, ending the informal phase of section 7 consultation. COE agreed to continue informal consultation, pending the Service's review and response of the revised Appendix 14, which included the contractor's pondberry survey report. COE and the Service planned to meet once again to consider the Services comments.

September 8, 2000

The Service requested that missing data in Appendix B of the Survey Report: Revaluation of Pondberry in Mississippi be provided. Also, other information was requested, including the location of pondberry colonies on Delta National Forest that were not surveyed and the computed floodplain for each colony surveyed (Appendix B) as it would exist after flood reductions.

October 3, 2000

The Service provided the COE with a written draft of our review and comment of the BA as published in the draft EIS, in which we disagreed with the COE finding the project would not likely adversely affect pondberry. The Service requested a meeting with COE to discuss this review, but COE responded that additional time was required to review the Service's draft document.

2. Appendix 14: Endangered and Threatened Species Biological Assessment

This section represents the Services review of the referenced appendix, in a continuation of informal section 7 consultation. The review is not specifically for the purposes of NEPA, though our comments and analysis here are relevant to assessing cumulative impacts of past, present, and future actions.

The Service has considered a variety of evidence to evaluate whether the proposed Pump project may adversely affect pondberry. No studies are available that specifically evaluate the ecology of pondberry by monitoring its response prior to and after impacts of a reduction in flood frequency, timing, and duration. Without such data, the Service has relied on four primary sources of information to develop a rationale; the ecology of pondberry, the ecology and hydrology of species and communities in bottomland hardwood ecosystems, the methods of sampling and statistically assessing plant populations, and data and theory of related ecological processes and patterns.

2.1. Flooding creates water-saturated soils and anaerobic soil conditions

The hydrologic environment of bottomland hardwood alluvial systems, as in the Yazoo Basin, "is a product of the frequency, duration, and timing of surface flooding" (Bedinger 1981). When flooded, air spaces in soils become replaced with water. The availability of oxygen for uptake by plant roots and for other biogeochemical processes in soils becomes limited or unavailable under flooded conditions, creating an anaerobic environment. Water saturation also significantly alters other physiochemical properties of soils including pH, reducing nutrient availability (Mitsch and Gosselink 1993).

2.2. Wetland plants have varying tolerances to anaerobic conditions.

Normally, plant tissues require oxygen for the essential life sustaining metabolic process of respiration. Aquatic and wetland plants possess structural and physiological adaptations to cope with periodic flooding, limited oxygen, and anaerobic conditions -- particularly during the growing season (Mitsch and Gosselink 1993, Ernst 1990). Morphological or structural adaptations of species in bottomland hardwoods include shallow root systems, abundant stem lenticels for gas exchange, and adventitious roots (Hook and Brown 1973, Whitlow and Harris 1979, Teskey and Hinkley 1977, Smith et al. 1986). Other adaptations include the development of special tissues creating air chambers in roots, arenchyma or lacunae, which allow oxygen to be diffused downward from plant tissues above water and saturated soils (Burdick and Mendelssohn 1990, Pezeshki et al. 1991, Mitsch and Gosselink 1993). Both of these morphological features utilize limited oxygen, enabling anaerobic respiration to continue by which the products of photosynthesis, sugar, are metabolized in the presence of oxygen to produce energy.

In contrast, other adaptations enable plant respiration without oxygen in an anaerobic environment. During these processes, alternative biochemical pathways metabolize the carbohydrate produced by photosynthesis by substituting other oxidizing compounds in place of oxygen (Smith and ap Rees 1979, Ernst 1990). The levels of photosynthesis, however, may be reduced under these conditions (Mitsch and Gosselink 1993). Other mechanisms avoid toxic accumulations of alcohol in tissues during anaerobic glycolosis by enzymes that break down alcohol or by alternative pathways that produce compounds other than alcohol (Crawford and Tyler 1969, MacMannon and Crawford 1971 Mendelson et al. 1982, Smith et al. 1986)

Anaerobic conditions are lethal to plants without morphological or physiological adaptations to flooding in bottomland hardwood systems. These plants are considered intolerant to flooding. The degree of tolerance to flooding, however, varies among the species of bottomland hardwood forests (Whitlow and Harris 1979, Kozlowski 1984). The most extensive studies of flood tolerance among woody plants in bottomland hardwood systems have addressed trees. In the Lower Mississippi Valley alone, the flood tolerance of over 60 species of trees and shrubs has been investigated and reported (e.g. Whitlow and Harris 1979), leading Theriot (1988) to propose a Flood Tolerance Index based on the dominant trees at site as an indicator of hydrology. None of the bottomland hardwood species are known, however, to actually require anaerobic conditions for growth and reproduction (Huffman and Forsythe 1981). Their survival, nevertheless, depends on the ability to tolerate the eco-physiological stress induced by flooding.

According to the National List of Plant Species that Occur in Wetlands (Reed 1988), pondberry is an obligate wetland species that occurs almost always (estimated probability >99%) under natural conditions in wetlands. This classification, prepared by regional and national panels of botanists and wetland ecologists, reflects the fidelity of pondberry and other obligate species to wetlands. Wetland plants, as defined by this manual, are those "that have a demonstrated ability (presumably because of morphological and/or physiological adaptations and/or reproductive strategies) to achieve maturity and reproduce in an environment where all or portions of the soil within the root zone become, periodically or continuously, saturated or inundated during the growing season (adapted from Huffman 1981)." In decreasing order of fidelity, other classes in addition to obligate species include those that usually occur in wetlands but are occasionally found in nonwetlands (facultative wetland), those equally likely to occur in wetlands or nonwetlands (facultative), those usually occurring in nonwetlands but occasionally in wetlands (facultative upland), and those that almost always occur in nonwetlands (obligate upland).

Pondberry exhibits several characteristics of a hydric species, including a very shallow root system, lacunae (arenchyma) tissue in roots than enhance oxygen diffusion, and abundant stem lenticels (Wright 1989a). The known occurrence of the species and its classification as an obligate wetland species, as in the Yazoo Basin, indicates it must possess other physiological and biochemical adaptations to a wetland environment as well.

2.3. Bottomland hardwood communities

Assemblages of plant species occupying similar environments comprise plant and forest communities. The species composition and distribution of bottomland hardwood forest communities within alluvial systems throughout the Coastal Plain have been studied extensively, beginning with early investigations recognizing their distinct composition in relation to floodplain hydrology and geomorphology (Wells 1942, Putnam and Bull 1932, Braun 1950, Penfound 1952, Shelford 1954). Brown and Lugo (1982), Conner and Day (1982), Wharton et al. (1982), Christensen (1988), Brinson (1990), Sharitz and Mitsch (1993) -- as summarized by Smith (1996), have provided reviews of the studies of BLH communities in relation to classification, dominant species, frequency and duration of flooding, anaerobic conditions, soils, landform, and disturbance (e.g. Franz and Bazzaz 1977, Huffman and Forsythe 1981, Clark and Benforado 1981, Parsons and Ware 1982, Good and Whipple 1982, White 1983, Hupp and Osterkamp 1985, Muzika et al. 1987, Faulkner et al. 1991, Shankman 1993).

The relationships between flood frequency and duration, landform, soils, and vegetation in bottomland hardwood systems lead to the zonal classification by the National Wetlands Technical Council (Larson et al. 1981, e.g. Clark and Benforado 1981). Different areas within a floodplain are inundated by floods at different frequencies and lengths of time. Since the floodplain landform and soils consists of an ecological gradient from more hydric to less hydric zones, a zone by this classification represents a distinct ecological community along the flood gradient. Zone 2, for example, is inundated or saturated by water permanently or nearly permanently in swamps, flats and sloughs throughout the growing season. Water tupelo and swamp tupelo, as well as other distinctive forest community types, are associated with Zone 2. In Zone 4, clayey soils are saturated from one to two months usually during the early part of the growing season, BLH communities are variously dominated by Nuttall oak, green ash, American elm, sugarberry, sweetgum, and other species (e.g. Wharton et al. 1982, Conner et al. 1990). Pondberry in the Yazoo Basin is most commonly associated with the gradients in Zone 3-4.

Touchet et al. (1990) found a distinct correlation between soil type, hydrology, and bottomland hardwood communities within these various zones in the lower Mississippi River Valley. The recognition of consistent BLH vegetation types in these zones was, however, problematic in the Mississippi River Valley (Conner et al. 1990). As Larson et al. (1981), Wharton et al. (1982), Conner et al. (1990), Sharitz and Mitsch (1993) and others have recognized, several factors affect the zonal classification of vegetation. First, the dominant trees of a BLH community type may naturally occur in more than one zone. These community types were assigned to respective zones according to their maximum tolerance to flooding. Second, the spatial or geographic boundary between some zones and BLH communities may not be distinct in some regions and localities where sharp or distinct changes in elevation within the floodplain landform are absent.
Finally, disturbances due to past changes in hydrology and timber management practices can obscure patterns of species composition in these communities (Sharitz and Mitsch 1993).

While site-specific applications of the zonal concept in some situations can be problematic, the zonal classification is considered a practical framework synthesizing the major ecological patterns and processes in bottomland hardwood systems (Wharton et al. 1982, Larson et al. 1980, Sharitz and Mitsch 1993). It reveals how flooding effects the composition and distribution of bottomland hardwood forest communities and species. These effects and relationships are well established and published elements of an ecological principal in bottomland hardwood ecosystems (e.g. Wharton 1980, Clark and Benforado 1981, Wharton et al. 1982, Conner et al. 1981, Conner and Day 1982, Theriot 1988, Gosselink et al. 1990):

> "The hydrologic environment is a product of the frequency, duration, and timing of surface flooding" (Bedinger 1981).
>
> "Species composition in bottomland communities is largely determined and maintained by timing, frequency and duration of anaerobic soil conditions which occur during the growing season" (Huffman and Forsythe 1981).
>
> "The frequency, timing, and duration of inundation and soil saturation are the driving forces behind the processes that affect both soil genesis and species composition" (Faulkner et al. 1991).
>
> "Both plant and animal species are determined by the flooding regime (Larson et al. 1981).
>
> "Flood waters and subsequent groundwater levels determine the type and productivity of vegetation in the floodplain. The hydroperiod, including flooding duration, intensity and timing, ultimately limits species composition and influences ecosystem structure and function" (Sharitz and Mitsch 1993).
>
> "The hydroperiod is the major determinant of plant species composition in BLH wetlands" (King and Allen 1996)

2.4. Changes in flood hydrology affect species composition and structure in bottomland hardwood communities

Given that the species composition, structure, and distribution of BLH communities are affected by flood hydrology, then "changes in [flood] stage and hydroperiod eventually lead to a change in the character and productivity of the bottomland forest (Gosselink et al. 1990). Such changes can be associated with natural or man-made alterations that either increase or decrease the hydroperiod.

For example, green tree reservoirs (GTRs) are man-made impoundments in bottomland hardwood stands that are flooded, typically, during fall and winter to provide waterfowl habitat (e.g. Rudolph and Hunter 1964). The kinds of plant species and their relative abundance in some GTRs, including trees and shrubs, has changed from those that are less water-tolerant to more tolerant as the hydroperiod increased (Fredrickson 1979, Newling 1982, Malecki et al. 1983, Schlaegel 1984, Karr et al. 1990, Guntenspergen et al. 1993, King 1994, 1995; Deller and Baldassarre 1998). Also, other alterations to flood frequency, timing, and duration both upstream and downstream of dams and river channelization projects have been considered to affect plant species composition and productivity of bottomland hardwoods (Fredrickson 1979, Conner et al. 1981, Reily and Johnson 1982, Miller 1985, Schnitzler 1994, Ward and Standford 1995, Schneider et al. 1989, Crandall et al. 1984, National Research Council 1992, Sharitz et al. 1990). When changes were observed by these studies, the typical response to an increase or decrease in hydroperiod involved an increase or decrease in the relative abundance, density, and growth of particular species.

2.5. A reduction in flood frequency may adversely affect pondberry

The COE surveyed 62 pondberry colonies in bottomland hardwood forest communities in the Yazoo Basin, most of which (52) were in the Delta National Forest (DNF). Thirty-one of these colonies (53%) currently are flooded on average one or more times every five years. After the project, only eight (13%) of these colonies will be flooded once every five years. Of the 62 colonies surveyed, the average colony is currently flooded once every six years. After the project, the average will decrease to once every 100 or more years. Overall, the project will significantly reduce the frequency of flooding to pondberry colonies on the DNF (Table 1). In contrast to the conclusions of the COE, we find that this reduction in the hydrological regime may adversely affect pondberry.

The change in flood frequency and its effect on hydrology represents a "disturbance." As defined by Pickett and White (1985), a disturbance is "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment." In this context, the change to flood frequency and hydrology is a disturbance that may directly and indirectly affect the growth, reproduction, and survival of pondberry.

The COE's rationale that the project is not likely to adversely affect pondberry is based on two primary conclusions: 1) the absence of a significant positive correlation between pondberry abundance and flood frequency, and 2) local rainwater ponding, instead of flooding, is the predominate source of wetland hydrology for pondberry in the Basin. As described below, the Service disagrees with this rationale and conclusion.

<u>A change in plant community composition may adversely affect pondberry</u>

Extensive studies and data reveals that plants interact or compete with other plants for space and resources such as light and nutrients (e.g. Connell 1983, Schoener 1983, Fowler 1986, Tilman 1987, Grime 1987). The outcome of competitive interactions depends on the extent that individual plants or their populations can garner or deplete limited resources and suppress other plants (e.g. Tilman 1982, 1985, 1988. As Goldberg (1990) has reviewed from the ecological literature, there are two situations when competition is an important factor affecting the structure and composition of plant communities. In both situations, there is great potential for an increase in plant growth for the successful competitor in response to an increase in resource availability. The negative response to plants experiencing competitive exploitation of resources can involve a reduction in plant size or biomass, reproduction, and survival (e.g. Tilman 1988). Successful competitors increase while others decline.

A reduction in flooding by the Pumps project will reduce the frequency, timing, and duration that soils are saturated by water in pondberry populations. These changes represent changes in resource availability. Frequently flooded pondberry sites under current conditions are generally unavailable or unsuitable for other plants that are not adapted to these hydric conditions. Changes leading to less hydric conditions, however, may increase the availability and suitability of these sites to other plants, leading to competition.

The current draft EIS does not describe the anticipated effects of reducing flooding to the composition and structure of BLH communities in the Basin. In the 1982 technical report on the Yazoo Area Pump Project (U.S. Army Corps of Engineers 1982), however, the COE concluded that changes in flood frequency from 2-year to 5-years, and 5-years to 20-years in the virgin overcup-oak and green ash stands in the DNF will "reduce tree growth, change site conditions,]nd allow encroachment by invader [plant] species." (pg. G-16). The environmental conditions in these stands is not different from those of pondberry colonies surveyed on DNF. We believe the 1982 assessment is an accurate though general prediction of anticipated effects. In accord with related information on the structure and composition of BLH, changes in species composition due to changes in flood hydrology, and the ecology of pondberry -- then reductions in flooding may adversely affect pondberry as a consequence of changes in community composition and competition.

Wright (1989a, 1989, 1990) recognized the potential role of competition to adversely affect pondberry, especially by other plant species that invade or become more abundant in light gaps created by a reduction or loss in the overstory tree canopy. He found pondberry to exhibit the characteristics of photosynthesis by plants that inhabit the shaded understory of a forest. Other species in these sites did not display any greater photosynthetic capability under shade than pondberry. Under natural undisturbed conditions, he found no physiological evidence that these other species might be superior competitors to pondberry. When the forest canopy was disturbed, however, he observed that vines and other plants invaded the light gaps, growing over and possibly suppressing pondberry. Changes to hydrology may not necessarily increase light gaps in pondberry colonies. A reduction in flooding in the Yazoo Basin, nevertheless, may establish the same mechanism and consequences by allowing an increasing number of less flood tolerant species to invade sites and compete with pondberry for available light, space, and nutrients. Wright (1989) concluded that "flooding seems critical in controlling potential competitors."

Wright and other participants at the 1990 Pondberry Workshop (U.S. Army Corps of Engineers 1990) identified the effects of competing vegetation to pondberry as a major concern following a reduction in flooding (see section 2.7). The workshop group decided that if flooding will be reduced at sites on or below the 5-year floodplain, then these areas must be specifically surveyed for pondberry. If pondberry occurred on such floodplains, the group concluded the impacts of the flooding to pondberry must be reassessed because competition and other factors may affect pondberry. For the current assessment, there is no evaluation of the potential impacts of competition to pondberry.

Reductions in flooding will increase drought stress

The biological assessment does not recognize the effects of drought, stem die-back in pondberry, and reductions in flood frequency. Stem die-back on pondberry has been observed in pondberry populations at various localities throughout the species range. The effect of die-back, however, cannot be disregarded in the current biological assessment as inconsequential to pondberry populations even though "Devall et al. (nd) suggested that since dieback was present in all populations examined that it [pondberry] has persisted for the last 20 years in the Missouri population." Stem die-back, as further described below, occurs due to drought, pathogens, and interactions between drought and pathogens. Patterns of persistent in Missouri or other populations where hydrology has not been altered are not accurate predictions of the future status of pondberry in the Yazoo Basin where wetland hydrology from overbank flooding will be substantially reduced. In South Carolina, as noted in an earlier COE biological assessment (U.S. Army Corps of Engineers 1996), Rayner and Ferral (1988) found that stem die-back was a factor leading to poor pondberry colonies. McDearman (unpublished data, U.S. Fish and Wildlife Service, e.g. U.S. Army Corps of Engineers 1996) also monitored substantial die-back and plant mortality during 1991-93 at a study site in the DNF. Devall et al. (2000) reported die-back of 33% of the stems monitored during June at the Shelby site in Bolivar County, MS.

The best available information indicates that stem die-back is related to fungal pathogens, drought, and interactions between a pathogen and drought. In unusual conditions, winter freezing may lead to die-back (Devall et al. 2000). Stem die-back, according to the assessment, "has been hypothesized to be fungal and/or drought-related, but could be characteristic of the species." (Appendix 14 pg. 14-9). We disagree with this conclusion. The effects of drought are more than merely a hypothesis. Potential pathogens have been identified, and as described below there exists a legitimate mechanism by which pathogens may exacerbate the adverse effects of drought. McDearman (1993) reported that within certain morphological constraints, the death of stems on pondberry can be a natural process of senescence. This data represented growth and die-back for one year at one colony in the DNF. Subsequent monitoring and studies of plant growth and decline (McDearman, unpublished) at this and adjacent colonies found that most instances of stem death were accompanied by abnormal patterns of sudden leaf wilt and death during the growing season on plants of all size-classes. This pattern is not indicative of senescence and die-back of old or large plants.

While dead stems have been variously observed in pondberry populations, Wright (1989a) first reported leaf senescence, summer leaf fall (facultatively deciduous), and twig die-back on pondberry plants in response to summer drought conditions in Arkansas. In the Delta National Forest, the pathological symptoms of active die-back were directly observed and monitored by McDearman at 10 pondberry colonies during 1991-93. The first symptoms were characterized by rapid leaf-wilt and sudden death of leaves and stems, during a late summer dry period, without leaf abscission. Stem, branch (more than one stem), or whole plant death followed during the subsequent fall and winter.

Abscission is a process by which leaves separate from stems along a zone of cellular abscission, and the exposed stem tissue at the point of separation are covered by excretions or new cells (Esau 1965). Since leaves died rapidly in the summer without abscission in the DNF sites, Dr. Douglass Boyette, a plant pathologist at USDA Agricultural Research Service, Stoneville, was consulted regarding the possibility that rapid leaf death was caused by a pathogen. After examining plants in the field and culturing stems in the laboratory, Dr. Boyette identified several potential pathogens, including *Diaporthe* sp., the cause of stem-canker. Stem-cankers on pondberry were frequently observed in the field.

Stem-canker and similar pathogens were identified from other cultures of stems collected by Devall in Arkansas (Devall et al. 2000).

The repeated occurrence of die-back syndrome during two consecutive years of late summer dry periods on the DNF suggests die-back is related to conditions of limited water availability. As Wright (1990) documented at pondberry study sites in Arkansas, soil water potential will decrease significantly during periods of summer drought. Wright also described the conditions of late summer drought stress to participants at the 1990 Pondberry Workshop, but it was not considered at that time to be a factor affecting pondberry in the DNF (U.S. Army Corps of Engineers 1990). The soils at Arkansas localities had significantly less clay than the soils of pondberry sites in the DNF. Thus, it was believed by workshop participants that the ability of clay to hold more water would serve to buffer pondberry against potential late summer drought stress in the DNF. Subsequent observations and monitoring of pondberry exhibiting symptoms of drought stress, as described above, indicate that Wright's concerns for drought stress are warranted in DNF and localities in bottomland hardwoods.

Interactions between drought and pathogens may occur due to the tissue damage caused by stem-canker. The wounds on pondberry stems caused by fungal pathogens can damage the internal plant vascular tissue than conducts water and nutrients. During periods of limited soil moisture, the effects of the fungal pathogen can increase the susceptibility of pondberry to drought stress and die-back (pers. comm., D. Boyette, USDA Agriculture Research Service, Stoneville, MS).

The ability of a plant to tolerate drought is partly related to the extent that leaf stomata regulate the rate of photosynthesis and transpiration. Stomata are the pores in leaves through which gases are exchanged and liquid water is transpired as water vapor during photosynthesis. Water is pulled from the soil through the vascular tissue of roots and stems to leaves as a result of the pressure or pull created in the water-tissue column during photosynthesis and transpiration. The size of the stomata change in response to water turgor in leaves and other factors. As water availability in the soil decreases, the stomata will become constricted in some plants to reduce the rate of photosynthesis and water transpiration.

Stomatal control, however, varies among different species of plants. As soil water becomes limited, the resistence of water to passage upward from the roots through vascular tissues increases, which also increases tension within the xylem tissue conducting the water. With unregulated stomata and photosynthesis during decreasing water availability, an excessive amount of conductance can lead to an irreversible collapse of the water conducting tissue (xylem) and/or blockage of the tissue with emboli by air-filled passages (e.g. Tyree and Sperry 1988, Jones and Sutherland 1991, Meinzer 1993), with subsequent die-back of stems and branches (Zimmerman 1983, Tyree et al. 1993.).

Studies of the ability of plants to tolerate water-saturated soils versus drought indicate a tradeoff between the ability of xylem to conduct water when it is readily available and to resist collapse caused by high water tension during drought. (e.g. Baruch 1994, ter Steege 1994, Loreti and Oesterheld 1996). The xylem is anatomically stronger and more resistant to collapse in plants inhabiting dry environments while plants in wet environments have xylem that may be more vulnerable to cavitation or emboli during periods of limited water availability (e.g. Alder et al. 1996). The resistance or adaptation to flooding is, generally, negatively associated with resistant to drought (e.g. Loreti and Oesterheld 1996). Thus obligate wetland plants such as pondberry that are tolerant of hydric wetland soils would not be expected to be as tolerant to periods of low water availability or changes in hydrology that reduce the frequency of flooding and soil moisture.

Wright (1989a) described the ability of pondberry plants to retain at least some foliage during drought-induced die-back as a “xeric adaptation.” The context of this adaptation, however, was relative to the poor ability of competing vines (*Brunichia ovata*) to resist wilting during summer drought at a natural site with unaltered hydrology. Periodic die-back of pondberry stems and plants in response to seasonally dry periods and/or pathogens affects the size and number of individual plants, colonies and populations. The long-term effect would depend on the frequency of summer drought relative to the frequency and magnitude of flooding during the growing season and changes in soil moisture capacity after flooding. While pondberry stems can re-sprout from the base following die-back, not all plants necessarily sprout (McDearman, unpublished data), especially after episodes of consecutive die-back. The number of new stem sprouts may or may not compensate for the loss due to die-back. A reduction in flooding, as caused by the Pumps project, may directly adversely affect pondberry by reducing soil water availability and increasing the susceptibility to drought, interactions with potential pathogens, and die-back. These effects when combined with an increase in competition from more drought-tolerant species may further reduce the density, abundance, and distribution of pondberry.

2.6. Environmental Correlations

The COE has concluded there is no relationship between variation in the density of pondberry, an obligate wetland species, and variation in flood frequency. In other words, the abundance of pondberry within a colony is a random feature in the BLH flood environment, where pondberry is as abundant at sites that flood once every two years as at sites that flood only once every 100 years. Contrary to the COE conclusion and rationale, the Service finds that the analysis of correlations between the density of pondberry plants in colonies at various sites to the current frequency of flooding at such sites is insufficient to discount any effect of flooding. More specifically, we disagree with the scope of the inferences made from the analysis, the sole use of bivariate correlation analysis for the analysis, the method by which sites were selected for study, and the selection and measurement of certain parameters at these sites.

Study Objective

The specific objective of the pondberry study is not described in the COE report. For observational or analytical sampling, one of the most important tasks is to lucidly describe the pertinent question or objective of the investigation (Cochran 1983). The COE report contains numerous correlation coefficients computed between measures of pondberry (stem density, stem basal area, stem height) and environmental features (flood frequency, elevation, percent canopy cover). Thus, it seems implicit that a purpose of the survey or sampling was to evaluate the relationship between some measure of pondberry "performance" and its environment – including flooding.

Selection of sample sites

Since part of the data collected has been subjected to statistical analysis (e.g. the correlation analysis), then the manner in which the data were collected represents a "statistical sample." A "sample" is a part of the population as a whole. The accuracy or validity of any inferences derived from such statistics depend on the extent that the samples are random and representative of the population. For robust statistical estimates, samples should be acquired randomly so that each has the same likelihood or probability of being drawn as another.

The sample unit for this survey is not clearly defined. As depicted by the data sheets, the sample unit for some parameters is the "colony", in which more than one "clump" may occur. These features should be described.

On the Delta National Forest, the sites or colonies selected for sampling were a subset of the total number of sites previously discovered by U.S. Forest Service staff. The biological assessment should describe how the sites or colonies were selected for the survey. Also, the location of all known pondberry sites that were and were not surveyed should be depicted on a topographic map. These maps should identify stands and other areas where the U.S. Forest Service has conducted pondberry surveys, with negative results.

Participants at the 1990 Pondberry Workshop (U.S. Army Corps of Engineers 1990) resolved that pondberry colonies located on the 5-year floodplain should be specifically surveyed. These surveys were important because the group considered that a reduction in flooding at or below the 5-year floodplain may adversely affect pondberry. Since surveys of potential habitat for new occurrences of pondberry on DNF were not conducted, we believe it is important to depict the extent that frequently flooded colonies were and were not included in the sample. Even though the actual elevation of pondberry occurrences that were not surveyed will not have been determined by ground survey, the approximate elevation and floodplain for each site should be tabulated based on topographic maps. One of the purposes of surveying and sampling, in our opinion, is to evaluate the number of colonies or size of pondberry populations relative to current flood frequencies and future flooding as reduced by the project. Such data on the size of populations and the locations of populations surveyed as well as those not surveyed would indicate the extent that the acquired sample is representative or random.

The number of sites or colonies sampled at different elevations (floodplains) can affect the value of the computed correlation coefficient. For a hypothetical example, if 10 known sites were located at an approximate 20-year floodplain and only one of these was sampled, then a sample of 6 from 10 sites on an approximate 10 year floodplain is a disproportionate sample. Since correlation evaluates the extent that one variable (e.g. pondberry density) will vary independently or dependently in relation to another variable (e.g. flood frequency), disproportionate sampling can fail to adequately represent the nature of such variation about the value of a variable (e.g. 20- year floodplain). Sampling or post-sampling correlation should consider the frequency of selected sample sites relative to the frequency of all such sites (surveyed and not surveyed) on the respective floodplain.

Plant Height

We had previously suggested that the COE sample plant height at each colony or site because plant size is generally an indicator of plant vigor, future mortality, reproductive performance (Werner 1975, Solbrig 1981, Westoby 1982, Hara 1984, Hutchings 1989). The indicator of interest, however, is not the average height of plants sampled. Instead, it is the size structure of colony or population as depicted by the frequency distribution of plants by size class. Plant populations typically display an uneven, skewed or asymmetrical distribution of size classes, usually with fewer large plants and an abundance of smaller individuals. Causes for different size-classes can include plants of different ages, but competition among plants also generates asymmetry in plant size structure, as in competition for light (Wiener and Thomas 1986, Westoby 1982, Wiener 1985, 1986, 19990; Wiener and Fishman 1994, Shabel and Peart 1994, Schwinning and Wiener 1998).

Size structure data is not available from the COE survey because samples were not made to compute “average” height. As the Service observed the survey team on August 11, 2000, instead of randomly sampling the colony with quadrats or other methods to measure the height of each individual plant, the survey team purposively selected a single plant that looked like what they considered as representing an “average” plant height. Only a single plant was measured. This is a biased estimator of plant-size and biased index of size-structure. The ability to accurately visually select a representative average plant is subject to error.

Since plant size-structure is usually skewed and asymmetric, other statistical measures of median or mode instead of the arithmetic mean (average) are more accurate of the central tendency of plant size in a structured population such as pondberry. The computation of correlation coefficients of “average” plant size and flood frequency, for example, is not statistically valid. Also, the average height or size of a plant in a colony or population is not as important as the size class structure in the population for the purposes of exploring vigor, growth, and other factors that may be indicative of suppression and competition (Figure 1). Such data can not be generated from this survey.

Canopy Cover

According to the described methods, canopy cover was measured with a densiometer. As above, on the two days Service staff accompanied the field survey crew, a densiometer was not used. Instead, canopy cover was estimated by surveyors looking at the overstory canopy, and visually judging its cover.

Plant Density

The density of plants (number of plants per colony area), according to the assessment, was one of several features that collectively were subjectively evaluated to assess “health” of colonies. Density is an important attribute, but it also has limitations. For example, two colonies can have the same density of plants (number of plants per unit area), but the total number of plants in one colony can be significantly different than the other. Number of plants, as an estimate of colony or population size, also is an important indicator of status. We recognize that the purpose of the survey was not to create a model to evaluate the size and characteristics of a minimally viable pondberry population. As a gross indicator of status, however, population size is a central feature of population persistence as affected by the demography of the population and the effects of the environment on the population (e.g. Menges 1991). All other factors being equal, the greater the number of plants in a colony and the population of colonies, then the greater the likelihood of population persistence. (see comments on Experimental units).

Experimental Units

The basic unit sampled by the survey was a “colony”, in which characteristics of plant density, height, stem diameter, and other associated environmental features (canopy cover etc.) were measured. As we would describe a colony, it is a distinct aggregation of pondberry stems growing in dense proximity, with a defined perimeter separated from other colonies. Pondberry is often but not always aggregated in colonies. Also, pondberry “populations” can consist of one or more colonies together with additional plants that are not distinctly aggregated in colonies. As in the Sweet Gum Research Natural Area in the Delta National Forest, there are at least 1500 pondberry plants distributed over the 40-acre site, most of which are not aggregated in a colony association (pers. comm., M. Devall, U.S. Forest Service). In a similar fashion, pondberry is widely but sparsely distributed throughout on portions of Compartment 4 on the DNF as well, without distinct aggregations. The survey and sampling protocol does not appear to include pondberry in areas of such low density, where colonies or aggregations are not distinctive.

While the environment (light, space, competition, hydrology, etc.) may certainly affect pondberry as associated with colonies, the experimental unit for the purposes of sampling and analysis should not limited to “colonies.” Colonies 39-43 are all located in the same forest management stand in the DNF, on the same soil series, in a ± 3 acre depression that stores rain and floodwater, dominated by mature Nuttall oak with a poorly developed stratum of herbaceous plant species.. Pondberry at this site was studied from 1991-94 by the MS Department of Wildlife, Fisheries and Parks. The “site” represents a relatively homogeneous environmental and experimental unit. We would agree that a “colony” represents a an appropriate unit and “stratum” for sampling, but other strata and units should also be considered (e.g. Cochran 1983, Elzinga et al. 1998, Schreuder et al. 1993, Eberhardt and Thomas 1991).

As recognized during the 1990 Pondberry Workshop (e.g. Robert Wright, U.S. Army Corps of Engineers), results of initial surveys should be evaluated to determine a system of stratification for additional surveys or analysis. At homogeneous sites with more than one colony, the relationship of pondberry to flooding and other environmental features can be stratified to approximate a population of colonies. The relationship to be examined by a correlation analysis would be the estimated total number of plants in the population at the site (all colonies) relative to flood frequency. This would represent a single observation in the correlation analysis, instead of five observations representing each individual colony with fewer plants. The same situation would exist at other sites, such as colonies 31A, 31, 30, 29A, and 29. The computed correlation coefficients, by these strata, will differ from those of the current analysis.

Correlation Coefficients

<u>Computations</u>

The variables (e.g. floodplain, density, etc.) are required to possess several statistical properties for a valid computation of a correlation coefficient, depending on the particular coefficient computed. The assessment does not report whether the computed coefficient is the Pearson product-moment coefficient, based on data with a normal (parametric) frequency distribution, or a Spearman rank order coefficient, based on data with skewed nonparametric frequency distribution. The Pearson product-moment coefficient requires that the frequency distribution of the observations for each variable possess a statistically normal distribution (Neter and Wasserman 1974). Variables such as colony density and floodplain (Figure 2) are highly skewed and not normal. These variables and observations should be numerically transformed to approximate a normal frequency distribution for the Pearson product-moment coefficient, or alternatively, the Spearman coefficient should be computed.

The current floodplain for each colony as reported in Appendix B is based on some type of assessment or hydrological model that is not described. During our September 6, 2000 meeting (see section 1) with COE, it was explained that the frequency of flooding for each colony was determined by a “point” method. The characteristics of this method, relative to the methods of hydrologic analysis described in Appendix 6 for the project, should be explained. For example, colony 29 is located on the 4.5-year floodplain, indicating the site floods on average once every 4.5 years. Since this is an “average” flood frequency, then the predicted flooding at the site will vary around the average, being flooded more frequently and less frequently than once each 4.5 years. The statistical properties of the flood frequency distribution are not described in the Assessment, but should be evaluated if available. If they are not normal (nonparametric), then the Spearman coefficient should be computed instead of the Pearson product-moment coefficient.

Using the raw data tabulated in Appendix B: Pondberry Data, we computed the Pearson product-moment correlation coefficient for the variables reported by COE, but our computations do not agree with the results reported in the assessment. For example, the correlation coefficient computed by COE for the relationship between colony density and floodplain was 0.063, while our computation was 0.31. For the relationship between colony density and elevation, the COE computation was 0.111 and ours (Pearson) was 0.37 We also computed the Spearman coefficient for each pair of variables (density and elevation = -0.18) , but these did not match the coefficients reported in the assessment as well. From the data in Appendix B, the values for some of the variables supposedly measured at each colony are missing. These missing data could have either been acquired in the field, but mistakenly omitted in the Appendix, or they were not sampled in the field. If these missing data are available, we would appreciate a copy of all raw data acquired at each pondberry colony site.

Inferences about cause and effect

As the COE described during our September 6, 2000 meeting, the results of the correlation analysis were important to their finding that this project will not likely adversely affect pondberry. Upon our review, we find that the use of such analysis is limited, however, in its scope and application. Correlation analysis as a basis for making inferences about cause (flooding) and effect (pondberry response) is particularly limited.

Correlation coefficients represent the extent that two parameters covary together (e.g. Sokal and Rohlf 1981). As in the relationship between pondberry density and flood frequency (flood plain), the coefficient examines whether the changes in the density of pondberry at sampled sites varies together with similar direction and magnitude as changes in the frequency of flooding at such sites. A positive correlation (greater than 0 but less than 1) exists when sites with greater than average pondberry density also have greater than average flood frequency. No relationship (zero correlation) exists when sites with greater than average density are equally likely to have either a greater or less than average flood frequency. Most of the correlation coefficients computed by COE in the Assessment were statistically nonsignificant, near zero.

Numerous authors have described the caution that must be used to avoid improper inferences about cause and effect using correlation analysis, as well as the type of experimental designs and statistical analysis to rigorously conclude causation (e.g. Eberhardt 1970, Sokal and Rohlf 1981, Romesburg 1981, Holland 1986, Eberhardt and Thomas 1991), The absence of any positive correlation between pondberry density, number of stems, etc. and flood frequency is not substantive evidence that density, relative abundance, or the performance of pondberry is not affected by flooding. In our opinion, COE has inappropriately used correlation analysis and the absence of a positive correlation coefficient to infer the absence of any role in flooding to pondberry.

In essence, the COE has erected a hypothesis that flooding does not affect different measures of pondberry status or performance (e.g. density), with an alternative hypothesis that pondberry performance increases with increased flooding. Since no statistically significant positive correlation coefficient was found for the association between pondberry performance (e.g. colony density) and flood frequency, the null hypothesis was accepted to be true with an improper inference of the ecological cause of flooding and its effect pondberry. The correlation analysis as used in the Assessment, however, is not a scientifically suitable method for making such conclusions. A hypothetico-deductive test approach using statistical tests of hypothesis based on experimental data is the most powerful scientific method to investigate causes and effects (Romesburg 1981). For pondberry, such an experimental design and analysis would evaluate the effects of reducing flood frequency, timing, and duration in a controlled setting. Since strong inferences depend on controlled experiments (Eberhardt and Thomas 1991), the study would be experimentally controlled so that pondberry plants would be randomly assigned to a "treatment" in which flood frequency, timing, and its duration also would be applied in a controlled fashion. By such studies, the characteristics of pondberry at each colony site would be statistically characterized prior to and after reducing flooding. Also, each colony site would be randomly assigned to a level of flood reduction. As typical with many ecological problems, these types of controlled experimental studies are not practicable or possible (Eberhardt and Thomas 1991, Murphy and Noon 1991).

In the absence of the ability, time, or funds to experimentally control and manipulate the exposure of one ecological variable to another, scientists have used the analysis of correlations of one biological or ecological attribute to another as they are observed to occur in nature. The process is considered to represent observations from a natural experiment (e.g. Holland 1996), without direct experimental control. The populations or units actually sampled and observed, however, are subject to extensive controls to insure the absence of confounding effects of other variables and factors (Holland 1996). Under these conditions, then the extent that a variable is or is not correlated with another represents an inference about their association. This is the process of induction (Hanson 1965, Harvey 1969, e.g.

Romesburg 1981), in contrast to deduction from experimentally controlled tests of hypothesis. The strength of scientific evidence accumulates when the association is observed over many trials, at which time a "law of association" may be evident (Romesburg 1981). Retroduction, however, is an improper attempt to use an association or lack of association as an explanation for the underlying biological or ecological process that cause the association. Instead, these retroductive explanations more accurately represent hypotheses about the underlying cause of association (Romesburg 1981).

The pondberry data lacks several important criteria for correlation analysis. We have previously described problems in the pondberry assessment with random sampling, the experimental units sampled, the methods by which some of the variables were measured, the need for stratification to establish environmentally homogeneous experimental units, and the statistical properties variables must possess to compute a correlation coefficient. The other criteria that seriously complicate the use of bivariate correlation analysis involve the fact that flooding has already been reduced as a consequence of past projects to many pondberry colonies. Also, the flooding may interact with other ecological variables, such as local ponding at a few sites (see section 2.7), to affect pondberry.

Because of the history of COE flood control projects in the Yazoo Basin, the current flood regime has been reduced from the natural system prior to flood control According to Galloway's (1980) analysis of historical stages and flows of the Mississippi and Yazoo tributaries, approximately 95% (3,895,000 acres) in the Yazoo Basin were historically flooded once every five years (the five-year flood). The two-year flood event inundated 94.9% of the region. As Wright expressed at the 1990 Pondberry Workshop, the ecological equilibrium for pondberry colonies in the DNF may no longer exist due to the effects of past flood control (U.S. Army Corps of Engineers 1990).

The historical flood regime as described by Galloway or by another analysis was not considered in the BA. Without portraying the effects of past flood control, the BA inappropriately depicts the associations between pondberry variables and the current floodplain where overbank inundation has already bee reduced as a natural and predictive association of the future response of pondberry to further reductions in flooding.

A correlation analysis to examine associations between ecological parameters of pondberry and flooding at sites in bottomland hardwoods is confounded by the fact that flooding already has been reduced by past flood control projects. Pondberry colony 22 for example, is currently flooded once, on average, every 17 years. Pondberry colonies near Shelby, in Bolivar County are currently on or above the 100-year floodplain. Bottomland hardwood forest communities typical of zones I-V, as well as pondberry, would not be expected to have naturally developed on floodplains that flooded less frequently than once every ten years (e.g. Wharton et al. 1982). The characteristics of pondberry in these colonies can not be attributed to the current flood frequency.

A time lag has occurred between the historical episodes of natural flooding in an unaltered Basin and current flooding moderated by flood control projects during the last 50 years. Any inference about the correlational relationship between current flood frequency and the attributes of pondberry requires a “constant effect” (e.g. Holland 1986) of flooding. An assumption of constant effect is not valid, however, since pondberry has been pre-exposed to a historically different, reduced frequency and duration of flooding. The attributes of pondberry as currently examined on an altered floodplain represents the attributes developed under less frequent flooding and in response to other uncontrolled factors such as timber harvest and regeneration. Some colonies have already experienced a significant reduction in flooding while others likely have not. For example, current flooding at colonies located at or below the current 5-year floodplain may not be as significantly reduced as colonies that are currently located on or above the 20-year floodplain. The implementation of past flood control projects has not been simultaneous over time for all pondberry colonies. Since the density and number of stems in pondberry colonies prior to flood control and the rate of change in response to incremental flood reductions during the past 50 years is not known, it cannot be assumed that the effects of a time-lag in flooding are constant, linear, and have been completed -- leaving the system in ecological equilibrium without further change.

The pondberry colonies located near Shelby and Merigold are currently on or above the 100-year floodplain. These colonies generally are dense, with a large number of stems (Figure 4). The Shelby colonies (colonies 47-48, 50-52) are actually part of the largest aggregation of colonies and population in the Basin. The particular association between these colonies and the 100-year or greater floodplain erroneously suggests by the COE’s inference from the correlation analysis that pondberry sites on the current 2-5-year floodplain could be reduced to a 100-year floodplain without any effect. This is an aberration of two circumstances.

First, local ponding of rainfall may interact and confound any attempt to depict pondberry status as a sole function of the current floodplain (see section 2.7). We would agree with the general decision-model from the Pondberrry Workshop (U.S. Army Corps of Engineers) that the adverse effects of past flood reductions to pondberry currently located on or above the 15-20 year floodplain are so significant that any further reduction in flooding to these colonies, while adverse, would not be ecologically critical. While flooding is no longer a important ecological factor regulating the Shelby colonies on the 100-year floodplain, there is evidence that local ponding of rainfall occurs within portions of this site (pers. com., M. Devall, U.S. Forest Service). As we describe in section 2.7, ponding of rainfall may be an important hydrologic component at some pondberry sites, but is not necessarily equivalent to flooding nor does it occur at all sites. Local ponding in lieu of flooding may continue, at least to some extent, to affect hydrology at the Shelby colonies currently located on the 100-year floodplain.

Second, the mathematical methods for computing a correlation coefficient involve the deviation for each colony from the average for pondberry density and the average for floodplain over all colonies. Shelby and Merigold colonies exert a large mathematical effect on the computation of the correlation coefficients among floodplain and density, number of stems, etc for pondberry in the entire Basin. Coefficients when computed for pondberry on the Delta National Forest, without the Shelby and Merigold colonies, are significantly different. Using the raw data reported, the computed Spearman correlation for the association between pondberry density and floodplain (flood frequency) is -0.34, which statistically significant ($p < 0.03$). In other words, density of stems appears decline in colonies as the frequency of flooding declines in the DNF (Figure 5). And since correlation only evaluates the linear relationship among variables, non-linear associations as suggested by the relationships on the DNF would not be detected.

The correlation presumes there has been a treatment effect of past flood reductions to pondberry. The rationale also assumes that current conditions (e.g. colony density) represents the species final response to the current floodplain. The inappropriate inference from these improper assumptions is that the current response of pondberry on any particular floodplain represents a future prediction of the condition of pondberry after flooding has been further reduced by the Pumps project.

Correlation analysis is further limited by the fact that the procedure examines only two variables at a time. The assessment includes the computed values of many correlation coefficients, each for a particular variable against flood frequency (or elevation as an estimator of flood frequency). Statements about the associations revealed by the correlation coefficients relate to the association of flood frequency, for example, to density and number of stems of pondberry. Pondberry, as any other species in the BLH system, however, may be simultaneously affected by many potentially interacting environmental features, including light, space, nutrients, water, and effects of man-made perturbations involving timber harvest, land use, and flood control. A complete understanding of the distribution and abundance of pondberry is the same problem faced by plant ecologists to elucidate the factors controlling or regulating distribution and abundance of any species. The problem is typically complex and multivariate in nature.

The pondberry colonies that existed 50 or more years ago on different flood plains before flood control have not been randomly exposed to a reduced flood frequency. By this requirement, pondberry on a historical 2 year flood plain would have been exposed by flood control to a 50-year floodplain with the same probability of a change to a 5-year floodplain.

Multivariate ordination and gradient analysis

Our recommendations to COE to conduct surveys and acquire additional data on the characteristics of pondberry at different flood elevations were not made for the purpose of conducting subsequent correlational analysis for cause-effect conclusions. We considered that the survey would provide first-level observational and descriptive sampling (e.g. Cochran 1983, Eberhardt and Thomas 1991). Our interest was additional data characterizing the distribution, abundance, and attributes of pondberry and its environment at different floodplains, relative to the projected floodplains created by this project. Subsequent stratification, additional analysis, or additional surveys would be evaluated relative to the nature of this descriptive data.

Plant ecologists often use multivariate methods of ordination analysis in an attempt to resolve the patterns of distribution and abundance of plant species in response to complex environmental factors and gradients, (e.g. Gauch 1982, Pielou 1984, Minchin 1987, Peet et al. 1988). The multiple variables involved in these analysis include the multiple factors that may be associated with species' distribution and abundance. These techniques include principal component analysis, reciprocal averaging ordination, detrended correspondence analysis, canonical community ordination, and canonical correspondence analysis. Generally, methods of ordination mathematically adapt or reduce these multi-dimensional data to a two-dimensional projection. The application of such methods should be considered for pondberry, though the available data and sampling methods by which it was acquired may likely be inadequate. Also, the analysis may likely be confounded by effects from past flood control.

From extensive studies of the distribution and abundance of plant and animal species in the environment, the theory of the plant community continuum (e.g. Austin 1985) and the realized niche (sensu Hutchinson 1957, e.g. Wiens 1989, Austin 1990) would predict that the performance of pondberry varies along a complex environmental gradient representing effects of the abiotic environment (resources) and competition. The gradient, as depicted by an ordination, is the multivariate x-axis of the two-dimensional graph. For most species the shape of the response to the gradient, which is the y-axis, is in the form of a Gaussian curve (Figure 6). The response curve also can be skewed or bimodal (Mueller-Dombois and Ellenberg 1974, Austin 1990, Collins et al. 1993).

An ordination or gradient analysis of pondberry has not been performed, but the continuum theory of plant distribution and abundance on an environmental gradient, which is accepted by most plant ecologists (Austin 1990), would predict a Gaussian response along the environmental gradient. The gradient would include the effects of hydrology and other variables. The shape of a Gaussian curve can vary, but several possible forms for pondberry are illustrated on an unspecified gradient (Figure 6). Each of these three hypothetical coenoclines depict the same location of an optimal response of pondberry on the gradient, but with otherwise different distributions elsewhere on the gradient. The purpose of this illustration is to depict that a change of the gradient, including a reduction in flood hydrology, would alter the location of the response on the gradient, affecting pondberry. Regardless of the specific shape of the Gaussian distribution or whether the response was bimodal or skewed, a reduction in flood frequency would shift the environmental or resource gradient and the species response to environmental optima. Optima or other areas, as a consequence, are displaced -- illustrating the areas where adverse effects may occur. The effects of past flood control, in our opinion, have already shifted flood frequency in some pondberry colonies outside the realm of natural conditions and environmental optima. Further reductions in flooding to pondberry within the 5-year floodplain may likely shift the environmental gradient outside the natural realm of pondberry within the Yazoo Basin.

As depicted in the form of bivariate scattergram plot for the correlation coefficient of pondberry density (and other parameters) against floodplain (flood frequency), the available data should not be interpreted to represent the performance of pondberry on a resource gradient. Ordination analysis, as previously described, may potentially assess patterns of pondberry distribution and abundance across resource and environmental gradients that include flooding.

2.7. Local hydrology is only more important than flooding when overbank flooding has already been substantially eliminated.

By COE rationale, the absence of any statistically significant positive correlations between pondberry and current flood frequency represents evidence that local hydrology and ponding of rainwater, instead of flooding, is the predominate source of hydrology for pondberry. We disagree with the basis for these correlations, as described above. The conclusion is an inappropriate retroduction (e.g. Romesburg 1981) that flooding does not cause or establish any hydrologic property of wetlands upon which pondberry depends for its habitat. Also, we disagree with the rationale or assertion that the 1991 Pondberry Profile and the 1996 Biological Assessment represents scientific evidence that local hydrology and ponding is ecologically more important than the hydrological effects of flooding. We find that no such evidence is presented and that the effects of reduced flooding cannot be ecologically discounted. The COE's conclusion surpasses the evidence considered by the pondberry experts at the 1990 Pondberry Workshop, the conclusions of these workshop participants, and the findings of the first biological assessment in 1991. In assessments after 1991, the conclusion from the workshop is not clearly distinguished that local hydrology and ponding is the predominate source of hydrology for pondberry colonies *where flooding has already been substantially reduced.* Where colonies are still frequently flooded under current conditions, further reductions to flooding will adversely affect hydrology and the species.

The 1990 Ponderry Workshop, 1991 Pondberry Profile, and subsequent assessments

The current biological assessment reaches an erroneous conclusion that:

> "The 1991 profile, the 1996 Biological Assessment, and this study indicate that pondberry colonies in the DNF are influenced more by local hydrology, rather than overbank flooding." (Appendix 14, Profile pg. 16).

The context of the results of the 1990 Pondberry Profile Workshop and the role of local hydrology are not accurately represented by these conclusions. On December 19, 1990, the COE Vicksburg District and its pondberry contractor (GeoMarine Inc.) held a workshop to evaluate a pondberry profile developed by GMI and to evaluate potential impacts of proposed flood control projects pondberry in the Yazoo Basin. Participants at the workshop included pondberry "experts" (U.S. Army Corps of Engineers 1990). One of the issues the group considered was the effect of reduced flooding to pondberry. The group concluded that:

> ". . . local drainage/surface water hydrology seemed more important to Pondberry's habitat requirements than overbank flooding particularly for these colonies located at or near the 20-year floodplain" (pg. iii, Minutes of Pondberry Profile Workshop, December 19, 1990).

The actual context of this discussion and conclusion was the effects of further reductions of flooding to pondberry, since existing flood conditions experienced by pondberry have been reduced by previous projects and do not reflect the natural regime. In the opinion of this group, pondberry colonies that are currently flooded once on average every 20 years, on the 20-year floodplain, are no longer significantly affected by flooding.   In other words, frequent flooding has been most likely eliminated as an important hydrological factor that ecologically affects or regulates pondberry. Thus, any further reduction in flooding would not likely adversely affect pondberry on or above the 20-year floodplain. The group concluded that the only remaining source of hydrology for such colonies would be from local ponding of surface water from rainfall, if it occurred.

In this context, then local hydrology would be more important than flooding for these particular colonies. The group did not conclude that for any pondberry colony, local hydrology was more important than flooding. Also, the group did not conclude that local ponding of rainfall established essential hydrology for pondberry in the Yazoo Basin. Furthermore, the group could not concede that pondberry below the 15-20-year floodplain would not be adversely affected by flood reductions.   More specifically, the group concluded that pondberry located on or below the 5-year floodplain may be adversely affected by a reduction in flooding, where additional surveys and assessments would be required. The results of this Workshop created a decision-making model that concerned pondberry below the 15-20-year floodplain, and particularly that on or below the 5-year floodplain.

Although the conclusion of this group was not fully explained in the 1991 Pondberry Profile, the dichotomy between overbank flooding to pondberry on the 20-year floodplain and local hydrology was accurately represented:

> ". . . local precipitation and hydrology have more of an influence on the pondberry colonies than overbank flooding, since the colonies on the Delta National Forest are located above the 15-20 year floodplain." (Refs).

By the time of the 1991 Upper Steele Bayou Project (refs) Biological Assessment for pondberry, the context of the Workshop is not clearly presented:

> "The general consensus appears to be that altering the wetland habitat by changing the water levels in an area is likely detrimental to the species. The USCOE (1991) through extensive field studies of pondberry within Mississippi and consultation with various experts, determined that only drainage activities which significantly alter the local hydrological regime of depresssions, ponds, sinks, or other areas governed by localized hydrology would adversely affect pondberry colonies" (pg. 11 U.S. Army Corps of Engineers 1991).

And for the 1996 Big Sunflower River Maintenance Project Biological Assessment (refs), the role of local ponding of rainfall instead of flooding is presented as the dominate source of hydrology, even for colonies below the 20-year floodplain:

> "The extant populations in Mississippi are all associated with bottomland hardwoods at elevations where rainfall/local hydrology dominates the hydrologic conditions at the pondberry colony site. Mississippi populations on the DNF are shade tolerant and found at elevations ranging from the approximate two-year to the 50-year floodplain on the lower Big Sunflower River Basin (USCOE 1994)." (U.S. Army Corps of

Engineers 1996).

In contrast to earlier assessments, the 1996 assessment is important because additional pondberry surveys had been conducted on DNF to determine elevation and flood frequency. While not all known pondberry colonies on DNF were surveyed, the COE reported for the first time that "[a]ccording to pondberry elevation data and historical hydrologic data for the Big Sunflower River, an average pondberry colony is located within the 6- to 7-year floodplain of the Big Sunflower River basin." (pg. 20)

Should formal consultation be initiated on the Big Sunflower project?

The Service concurred with the COE finding that the Big Sunflower River Maintenance project is not likely to adversely affect pondberry mostly on the basis of the COE assessment that the project would cause only "a 2-3 day reduction in the headwater flood duration within the two-year floodplain of the Big Sunflower River" (U.S. Army Corps of Engineers 1996). From our review of additional colony and floodplain data from the Pumps project, we have several questions concerning the Maintenance project that may or may not represent new information and effects not previously considered. This may be the basis for initiating formal consultation on the Big Sunflower project.

- **To what extent will the Maintenance project reduce flood frequency, in addition to duration, to the pondberry colonies reported by the Pump project? Will these colonies experience a 2-3 day reduction in headwater flood duration or will effects differ?**

- **What methods were used to predict a 2-3 reduction in flooding? Are these methods the same as used in the BA for Pumps Project? If not, how do predictions of a reduction in flood frequency, timing, and duration vary by these different methods?**

- **For the areas located at or below the 2-year floodplain, regardless if pondberry is known to occur in such areas, will the project reduce flood frequency and duration?**

- **The COE reported that the "2-year floodplain habitat of the Big Sunflower maintenance project area would be reduced by 1,989 acres (bottomland hardwoods)." Is this the area of a 2-3 day reduction in headwater flooding, and if not, what is the nature of this reduction? Is pondberry known to occur in this area, and if not, what surveys were conducted?**

- **Would the COE conclude, as in the Pumps BA, that any pondberry colony regardless of the current flood frequency, timing, and duration would not be adversely affected by a reduction in flood hydrology because of the hydrologic predominance of local ponding of rainfall to the ecology of this species?**

The Pumps Assessment: No direct evidence for the hydrologic dominance of local hydrology rather than overbank flooding

This assessment clearly identifies pondberry colonies below the current 20-year floodplain, and within the 5-year floodplain, where flooding will be reduced. Beginning with the 1990 Pondberry Workshop, a model was created for the assessment of impacts that would not likely adversely affect pondberry. A key to the model concerned whether the flood frequency at colonies had already been reduced to such an extent that it was no longer operating as a significant hydrologic regulator. The statement in the current assessment is not true that the COE through extensive field surveys and "consultations with various experts" determined that only projects that alter local hydrology, and not flooding, would adversely affect pondberry (Appendix 14 pg. 14-8). As previously reviewed, the experts consulted during the 1990 Pondberry Workshop concluded that reducing flooding to pondberry at or below 15-20 year floodplain, and particularly the pondberry at or below the 5-year floodplain, may adversely affect the species. The current assessment reaches a significant new conclusion that was not previously considered by experts consulted at the Workshop. By the current assessment, the ecology of pondberry is dominated by local hydrology and ponding of rainwater, regardless of overbank flooding at any frequency. This is a crucial conclusion that, if correct, would establish significant new scientific information on the role of local ponding to wetland species such as pondberry in a bottomland hardwood ecosystem.

The conclusion is made, however, without any direct evidence. If local hydrology and ponding were dominant, then pondberry colony sites would exhibit standing water from local rainfall extending by some duration of time into the growing season. These and other features would constitute the characteristics of a hydroperiod, involving the depth of ponding, its duration, and seasonal and annual frequency (e.g. Mitsch and Gosselink 1993). These features can be directly measured, but the only provided by the assessment for their existence concerns the distance from each colony site to the nearest body or site of standing water. The distance to water does not provide evidence that a pondberry site has the necessary depressional topography or volume to sufficiently store rainfall in a ponded fashion at a depth, duration, and frequency to override the influence of standing water from overbank flooding. Furthermore, the assessment notes that "[n]one of the colonies surveyed at DNF were found in standing water."

In our review of the scientific literature on pondberry as well as the ecology of bottomland hardwood communities, we are unable to find any references to studies that have identified local depressional ponding of rainfall, rather than flooding, as the most important ecological regulator of pondberry or plant or forest community composition at a site. The scientific paradigm for hydrology in bottomland hardwood forests remains as flooding. Gosselink et al. (1990b) describes flooding as the common understanding of hydrology in BLH communities:

> "Key hydrologic elements of bottomland hardwood forest ecosystems are storage volume; frequency, duration, depth and timing of surface floods; flow velocity; soil saturation; and infiltration rate." (pg. 348).

They also describe a common role of depressions, such as oxbows, as sites for storing flood waters:

> "Depressions on a site (e.g. oxbows) that temporarily hold water following the recession of a flood give rise to detention storage. The stored water eventually flows out through backwater swamps, evaporates, or perculates into the soil." pg. 364.

Scott et al. (1990) similarly considered the role of depressions in the BLH system as providing additional storage of flood water:

> "Natural ponding contributes to a slowing of overland flows during flooding and provides areas of standing water and sediment deposition following drawdown. Many of the development activities considered in this analysis result in reduced ponding." Pg. 418.

Such ponds and depressions, however, are significant geomorphic features – as oxbows.

Elsewhere in the southeastern coastal plain, depressional wetlands with distinctive vegetation and hydrogeomorphology have been well recognized, including Carolina bays (Sharitz and Gibbons 1982), cypress ponds and domes (Ewel and Mitsch 1978, Ewel 1998), non-forested upland ponds (Sutter and Kral 1994, LaClaire 1995), and Grady ponds (MS Museum of Natural Science). For some of these and other non-alluvial depressional wetlands, hydrologic data is available on the water budget, e.g. net precipitation, evapotranspiration, change in water volume stored per unit time (e.g. Mitsch and Gosselink 1993, Richardson 1983, Heimburg 1984, Kantrud et al. 1989). These non-alluvial wetlands also are characteristically distinguished by substantially different vegetation types from the surrounding and adjacent habitat. The predominate source of water in these depressional wetlands is rainwater and groundwater, with no inlets or outlets for surface water, with little to no surface drainage from adjacent lands..

The hydrogeomorphic, hydrologic, and vegetative features of the depressional rainwater ponds the COE claims to exist have not been assessed or described. No such descriptions or data exist either in the assessment or elsewhere in the scientific literature for pondberry within a bottomland hardwood forest system. The hydrogeomorphic characteristics for such local depressional wetlands, with or without pondberry, has not been assessed in the Basin. Whether or not local ponding actually occurs for the vast majority of pondberry colonies is unknown. More definitive data or direct observations of local ponding by rainwater and the hydrologic profile of ponding relative to flooding is required to discount the role of flooding and to substantiate local hydrology as the dominant source of hydrology to pondberry. Such data would represent the water budget of these ponds or, more minimally, the drying scores (Snodgrass et al. 1996, 2000) of the annual hydroperiod. Until such information is available, we consider the hydrologic role of local rainwater-ponding as a hypothesis, rather than substantial fact.

We recognize that depressional areas capable of storing rainwater exist at a few pondberry colony sites in the DNF. This is based on pondberry monitoring studies of plant growth, die-back, and mortality during 1991-94 by the MS. Department of Wildlife, Fisheries and Parks Museum of Natural Science, as supported by the Service, at two sites in Compartment 16 in DNF. One of these sites includes pondberry colonies 39-43 of the Pumps biological assessment. Both sites are depressional areas, totaling about 6 acres, where winter precipitation can accumulate and pond portions of the area with standing water. The study entailed monitoring during two periods each year, late-winter and early spring, and late-summer and early fall. We were unable to recognize the study sites as depressional rainwater storage areas, due to the slight topographic relief, until we actually observed ponded water with no inflow or outflow during the first year of investigation. Both pond are located in stands of Nuttall oak. The vegetation in lower center of the pond, however, is distinctively more hydric with a few cypress, water elm, and button bush, with an open gap in the canopy where trees and shrubs are absent. The depth of standing water due to rainwater storage was not sufficient to flood all pondberry colonies in the depression. Rainwater was stored as standing water from 30-60 days into the growing season of pondberry. During the flood of 1991, the depression stored floodwater to a greater depth inundating more colonies than that achieved by rainwater alone during susequent non-flood years. Thus, inundation by overbank flooding and the storage of such flood water still affected the hydrology of the site even though the depression is capable of storing rainwater during winter and early spring. During dry winter and spring seasons, as in 1999-2000, no rainwater was ponded or stored in these two depressions.

In addition to the six colonies in the depressional ponds, the monitoring project including four adjacent colonies in the same compartment. Local ponding from rainwater did not occur in these adjacent colonies. Two of these colonies received standing water from the overbank flood. Also during this period we conducted general reconnaissance surveys at pondberry locations in the Sweet Gum Research Natural Area, an area which included colonies 36-38, and at other locations on the northern end of the forest, which included colonies 22-28. None of these areas or colonies had standing water as a consequence of local hydrology during later winter or spring during the early growing season of pondberry.

Local ponding and overbank flooding can in fact hydrologically interact at the depressional ponds previously surveyed, under current flood regimes as well as historically. At the extensive and large colonies at the Bolivar County sites near Shelby (colonies 47-48, 50-52), evidence during current studies suggests that portions of this site may experience local ponding (pers. comm., M. Devall, U.S. Forest Service). While ponding of rainwater and floodwater does indeed occur at a few colony sites in the DNF, until other data or surveys are completed it appears that such features are an exception rather than a rule for pondberry colonies in the Yazoo Basin.

<u>Other Effects</u>

The COE's conclusion that essential hydrology will be maintained by local ponding, rather than flooding, eliminates the issues concerning the effects of plant competition, drought, and plant die-back. Since we do not agree that local ponding is the dominant source of wetland hydrology for pondberry, we find that the project may increase plant competition in the pondberry community and reduce pondberry growth and survival due to the additional effects of drought and pathogens.

3. Conclusion

The precautionary principle when applied to science and the Endangered Species Act, as advocated by the National Research Council (National Research Council 1995), requires the burden of proof in the face of uncertainty to demonstrate that the proposed project will not adversely affect pondberry. This is consistent with the intent and purposes of section 7 consultation since federal agencies “must insure” their actions are not likely to jeopardize the continued existence of listed species. The COE’s finding of “not likely to adversely affect” pondberry is, by default, a conclusion that the project is not likely to jeopardize the continued existence of the species. The determination of whether the project will jeopardize the continued existence of pondberry is, by the Endangered Species Act, the responsibility of the Service upon the formulation of its biological opinion that culminates formal consultation with the COE. Upon our review of the COE draft EIS and Biological Assessment, we find sufficient scientific evidence and rationale that this project will likely adversely affect pondberry. Accordingly, formal consultation is warranted. The Service can only concur with a finding of not likely to adversely affect when there is no likelihood of an adverse effect (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

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Table 1. Current baseline conditions of flooding and number of pondberry colonies, compared to conditions with the Pumps project for pondberry colonies surveyed on the Delta National Forest.

Flood frequency	Current Conditions		Conditions with Pumps Project	
	Number of Colonies	Proportion of Colonies	Number of Colonies	Percent
0-2 year	9	0.18	2	0.04
2-5 years	22	0.45	6	0.12
5-10 years	9	0.18	5	0.10
10-15 years	2	0.04	3	0.06
15-20 years	7	0.14	4	0.08
20-100 years	--	--	16	0.27
> 100 years	--	--	16	0.33
Average	6-year floodplain		> 45-year floodplain	

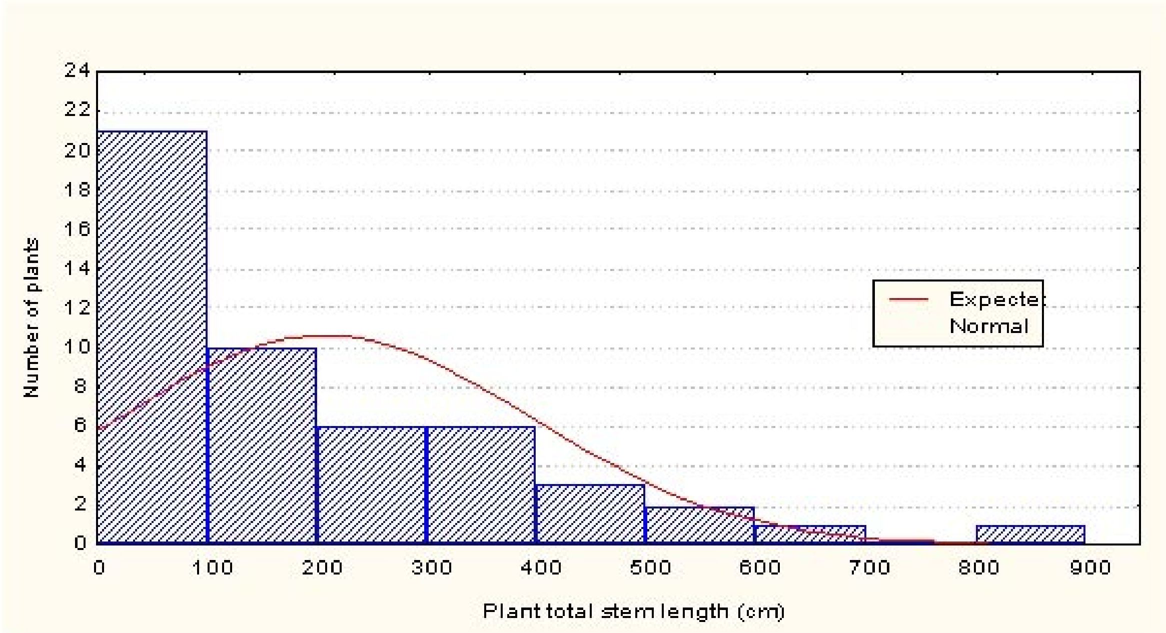


Figure 1. Pondberry plant size structure in a colony, during 1991, in the Delta National Forest. Plant size, from random 0.25 m^2 quadrats, measured as the total length of all stems. Size structure is skewed, without a normal statistical distribution, with fewer large plants and more small plants. Data from McDearman, FWS, unpublished.

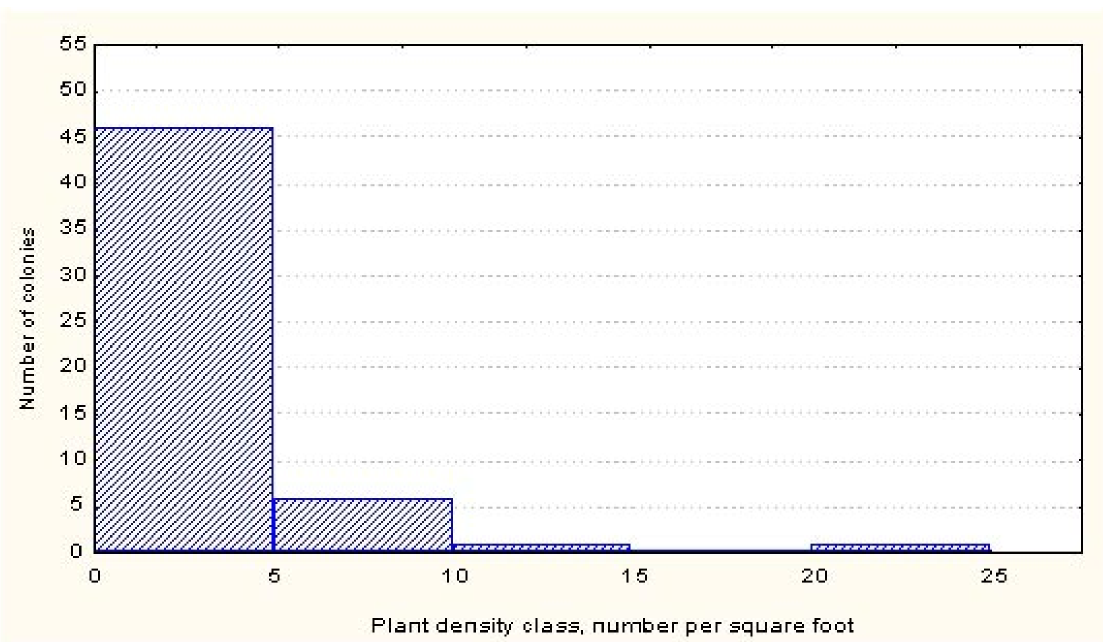
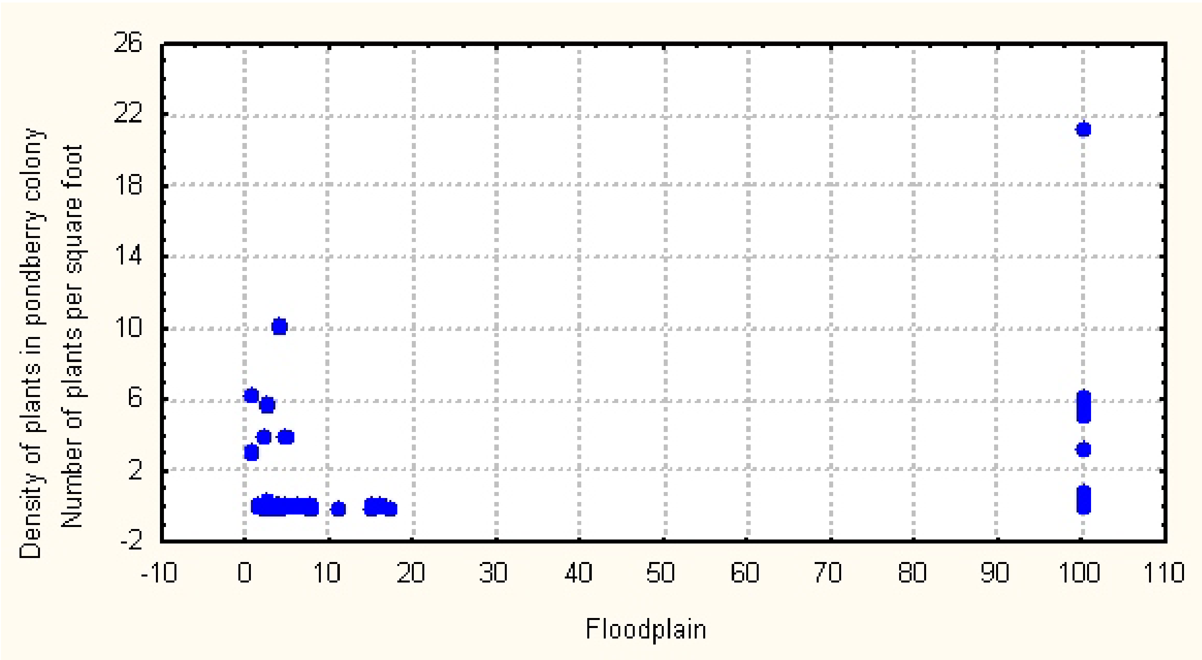


Figure 2. Plant density in colonies surveyed by COE in Yazoo Basin, with skewed nonparametric frequency distribution.



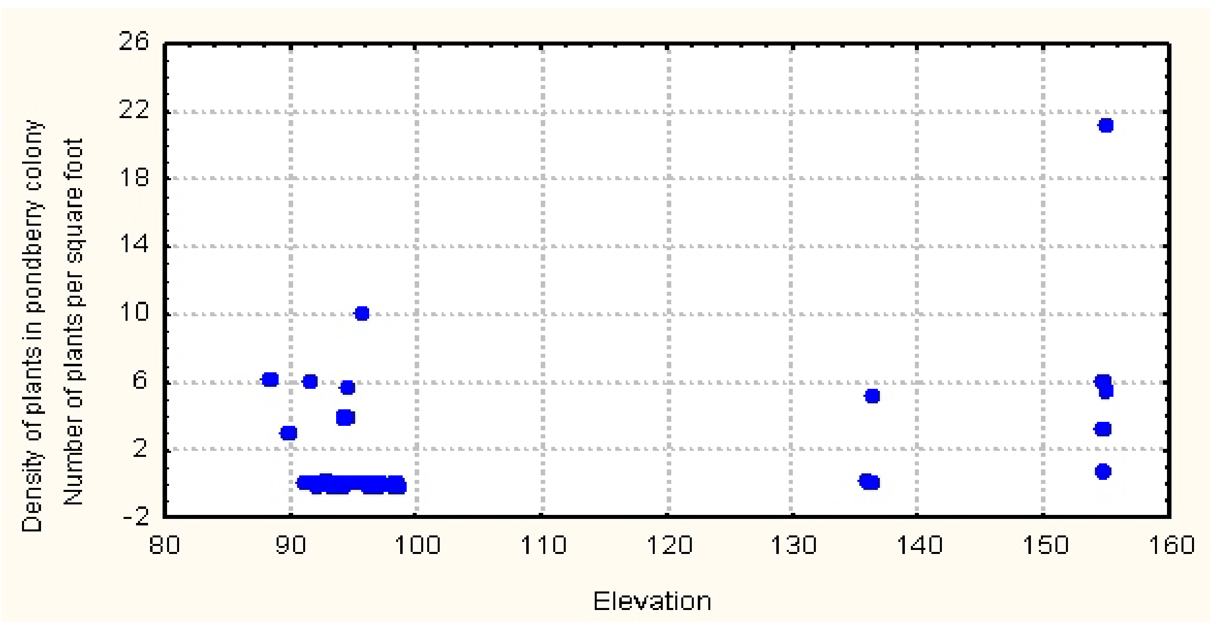


Figure 3. Density of pondberry plants in colonies surveyed by COE relative to elevation and floodplain. COE correlation coefficient for association between density and elevation and density and floodplain is, respectively 0.111 and 0.063. Our computation of the Pearson product-moment coefficient is 0.37 and 0.31.

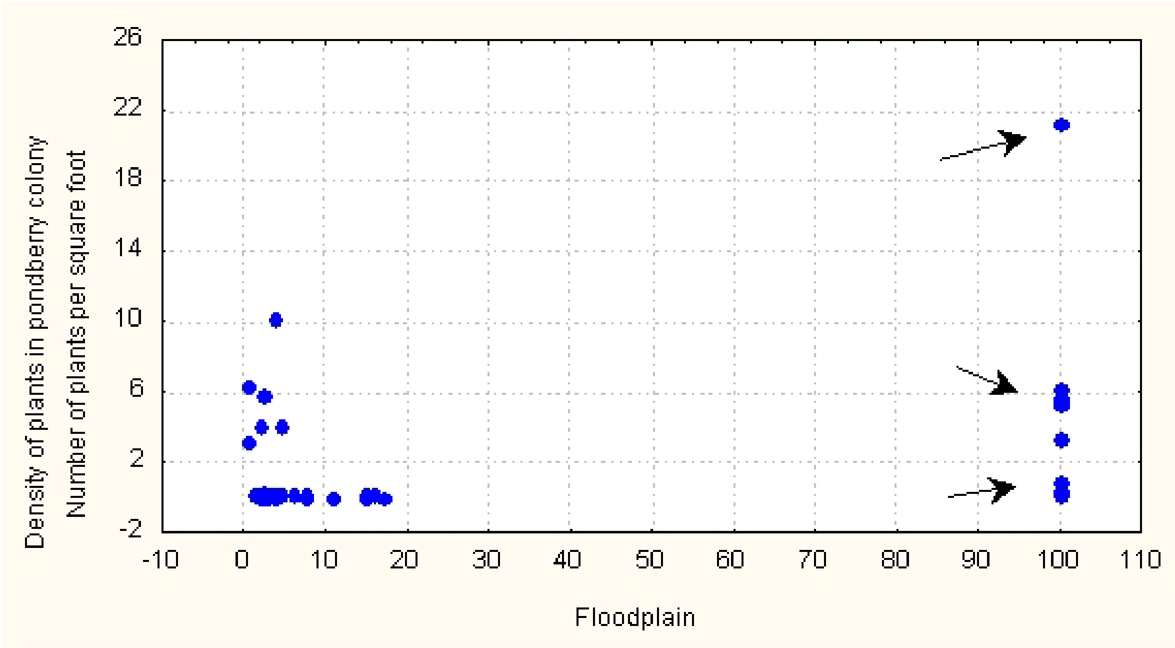


Figure 4. Pondberry plant density in colonies relative to the floodplain (years). All colonies on the 100-year floodplain (arrows) are the Shelby and Merigold sites.

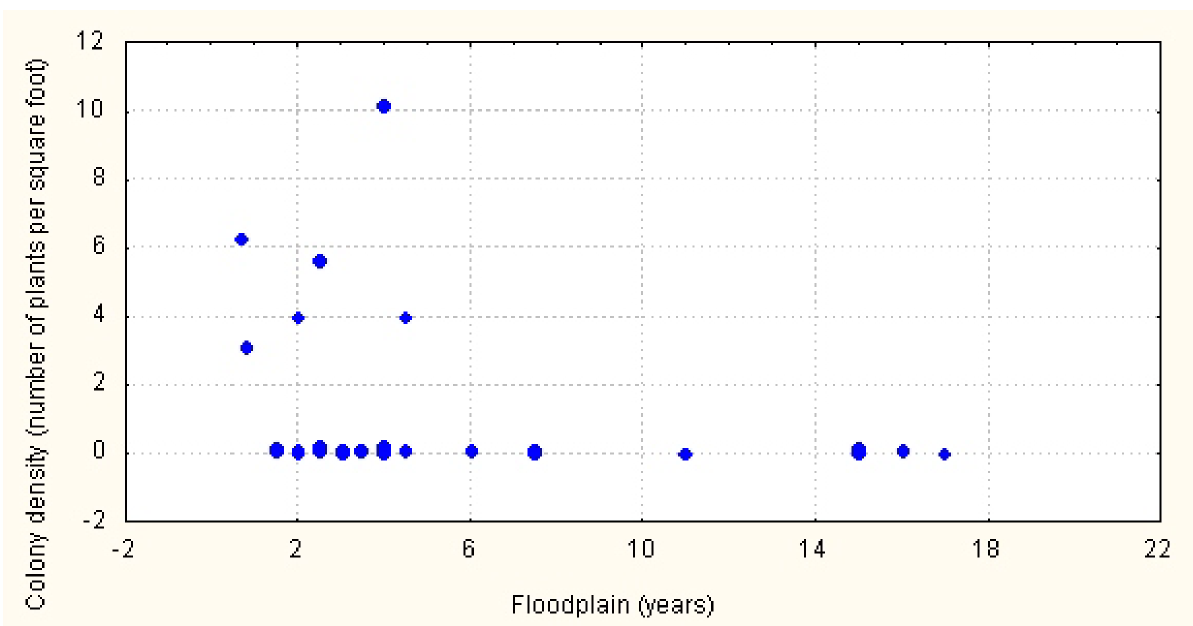


Figure 5. Relationship of plant density in colonies and floodplain on the Delta National Forest, indicative of a non-linear association.

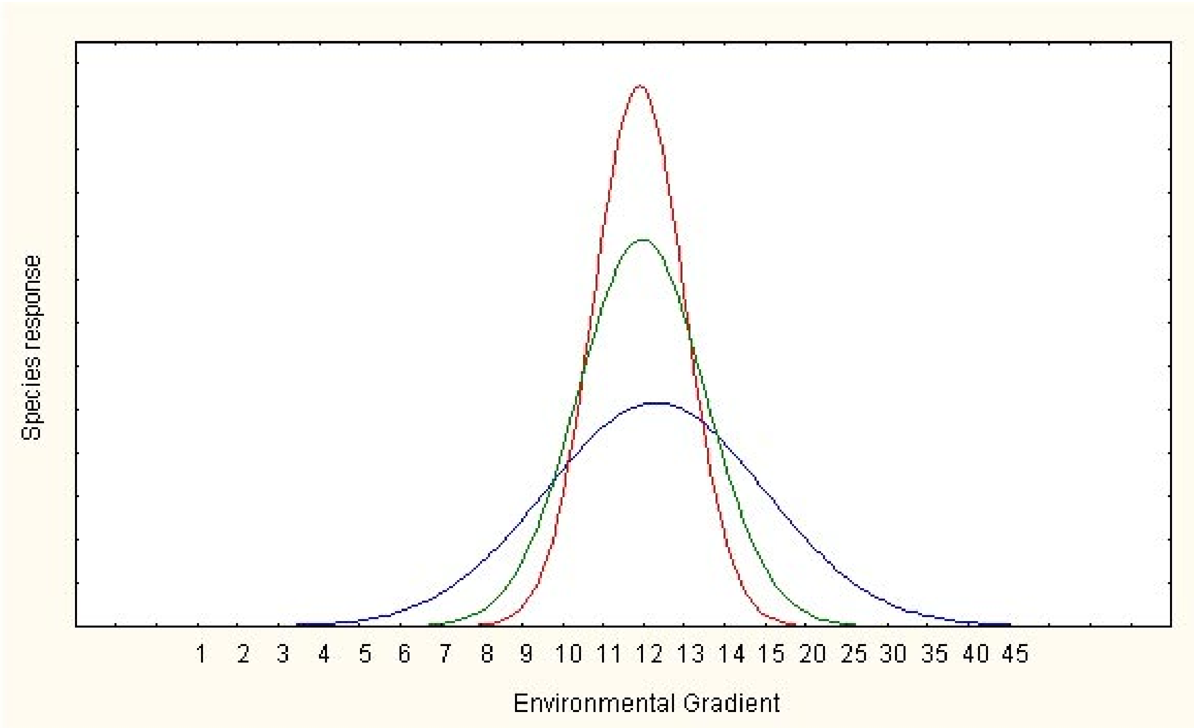


Figure 6. Examples of three hypothetical gaussian curves for pondberry response to the environmental gradient. Scale values on the gradient (x-axis) provided for reference points.